The sPHENIX Forward Upgrade
(and ePHENIX)

QM 2012

(8/17/2012)

Joe Seele

(RIKEN BNL Research Center)

- Physics Potential at Forward Rapidity
- Detector and Studies
- ePHENIX Physics and Detector Configuration

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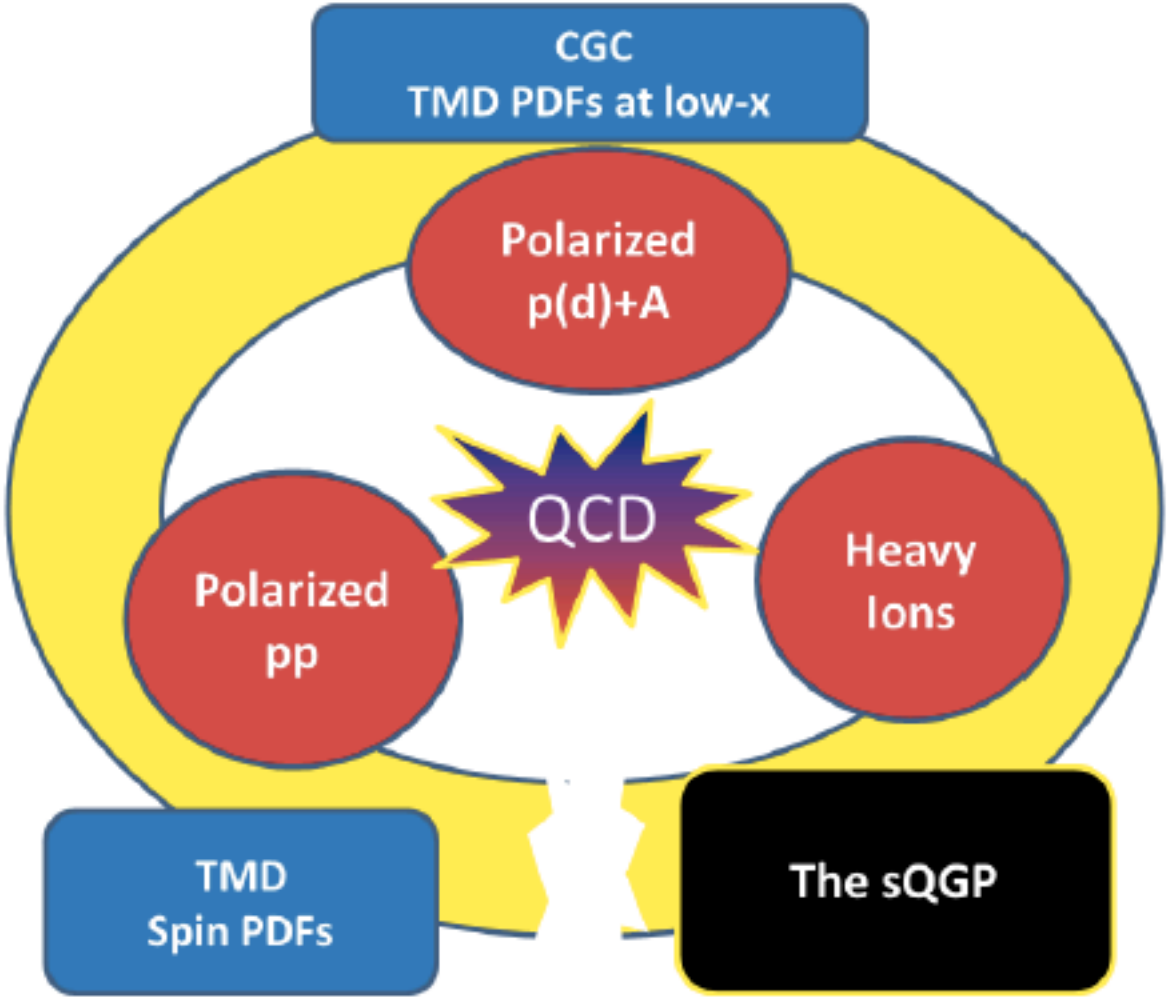
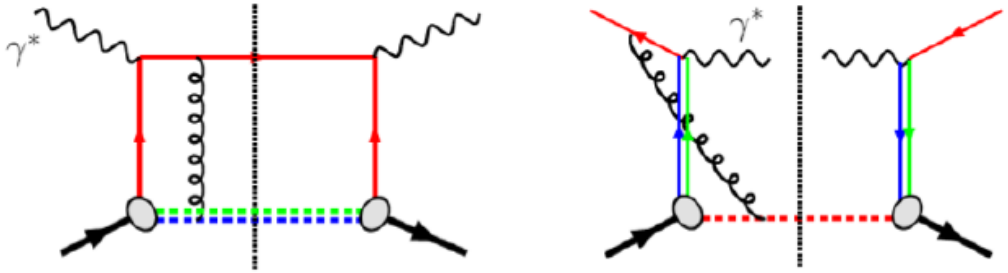
Physics at RHIC

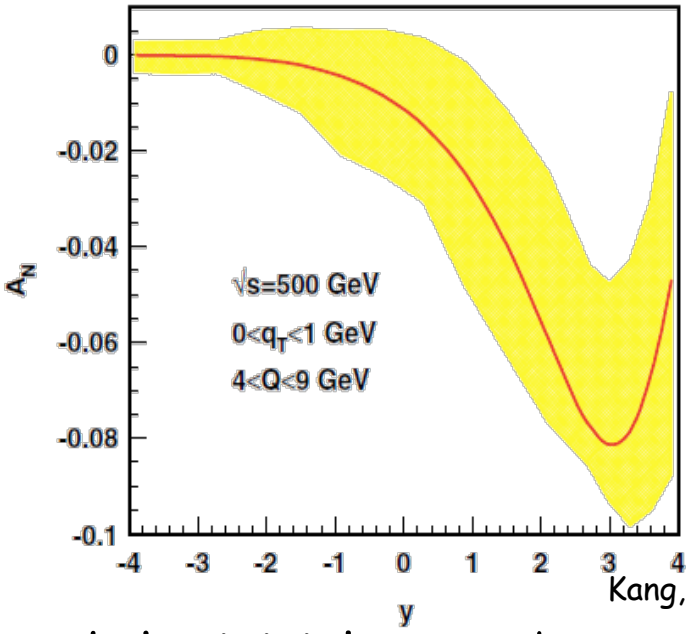


Forward Spin Physics

- Focus on transverse spin physics where empirically all the signals are in the forward direction (high-x physics)
- An elegant test of Transverse Momentum Dependent pdf factorization/description through measurement of forward Drell-Yan pairs

sign flip in asymmetry between DIS and DY





Kang, Qiu, PRD81

- Correlations between forward jets and the initial proton's spin direction give information related to the orbital angular momentum of quarks in the proton

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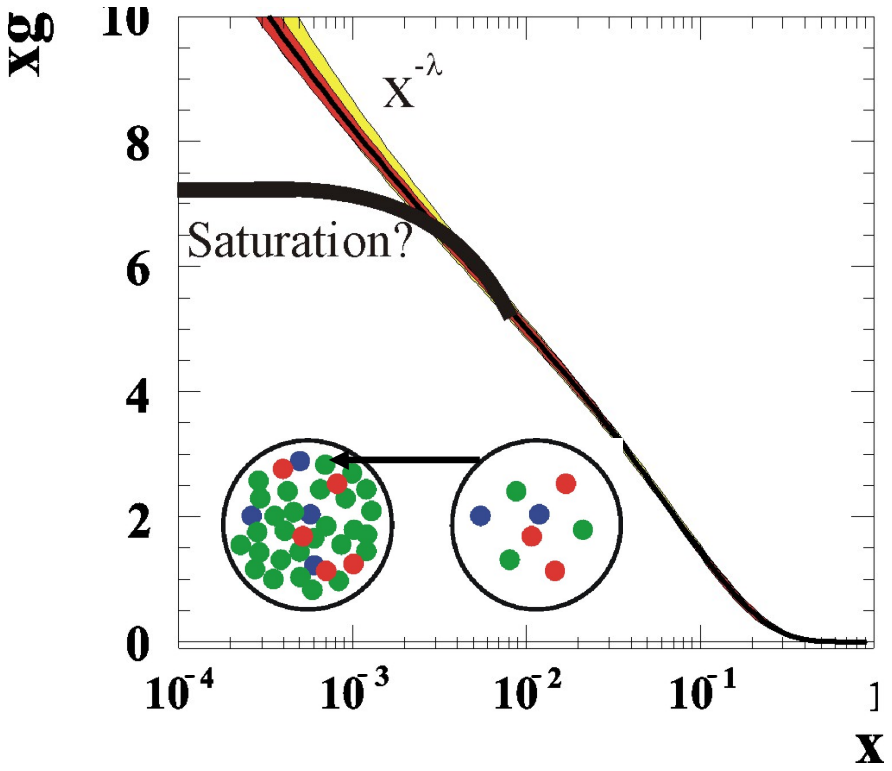
Forward CNM Physics - I

- The forward region also corresponds to the low-x region where saturation is expected (below a scale Q_S) and/or a CGC description of the data is relevant

- As in other QCD related phenomena, many measurements will be needed to substantiate and understand the validity of a CGC as the description of gluons in the nucleus.

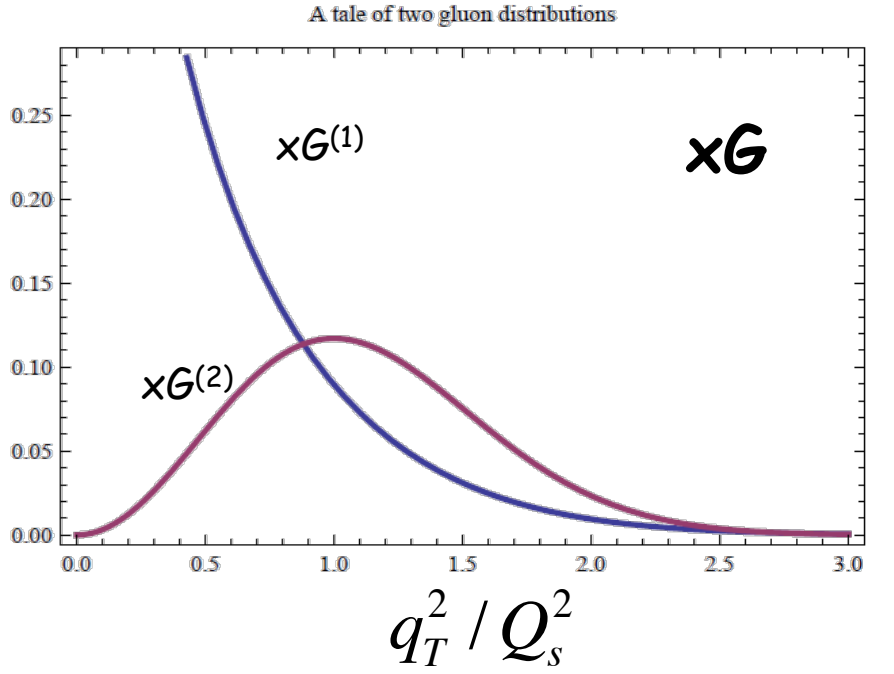
- A single unified framework should be able to explain phenomena seen both at RHIC and the LHC.



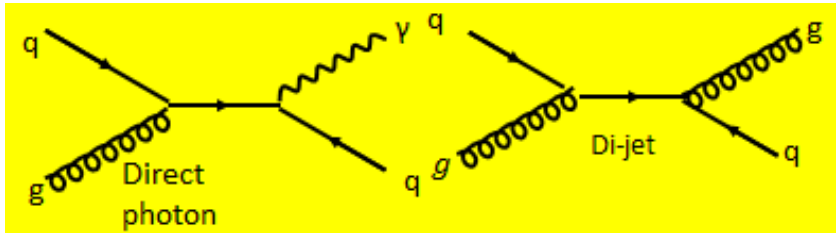
A major push is to observe saturation experimentally, and understand and map out the x and saturation scale, Q_S, dependencies

Forward CNM Physics - II

- G now comes in two flavors $G^{(1)}$ and $G^{(2)}$ in the low-x limit
- All CS described using $G^{(1)}$ and $G^{(2)}$
- Measure G's via γ-jet, dijet



PRD 49, 2233, 3352
NPB 529, 451



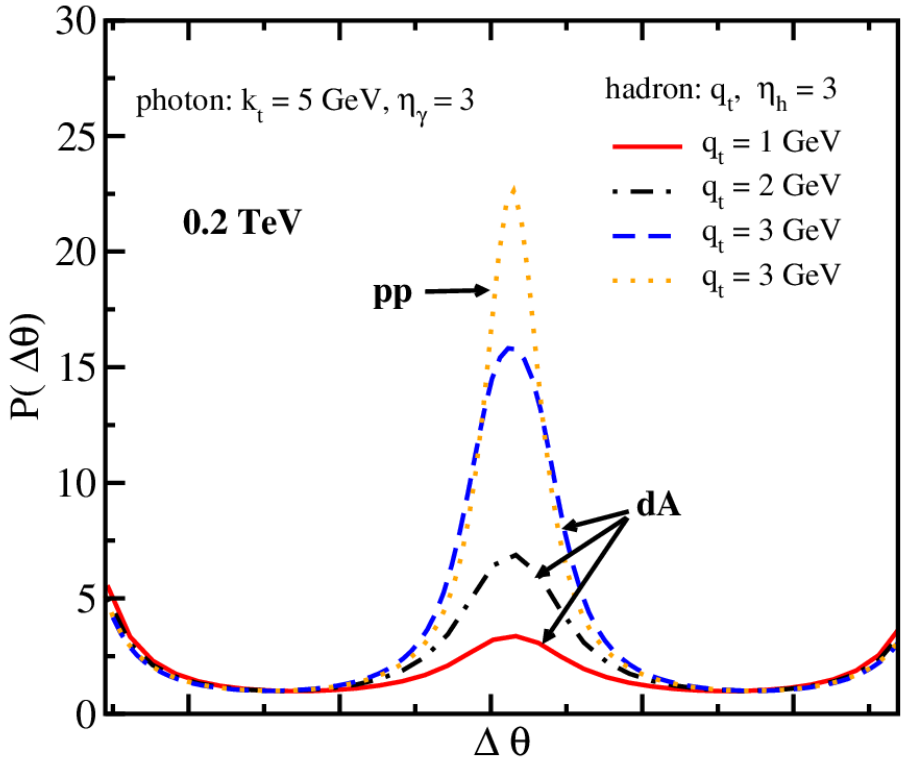
	DIS and DY	SIDIS	hadron in pA	photon-jet in pA	Dijet in DIS	Dijet in pA
$G^{(1)}$ (WW)	×	×	×	×	√	√
$G^{(2)}$ (dipole)	√	√	√	√	×	√

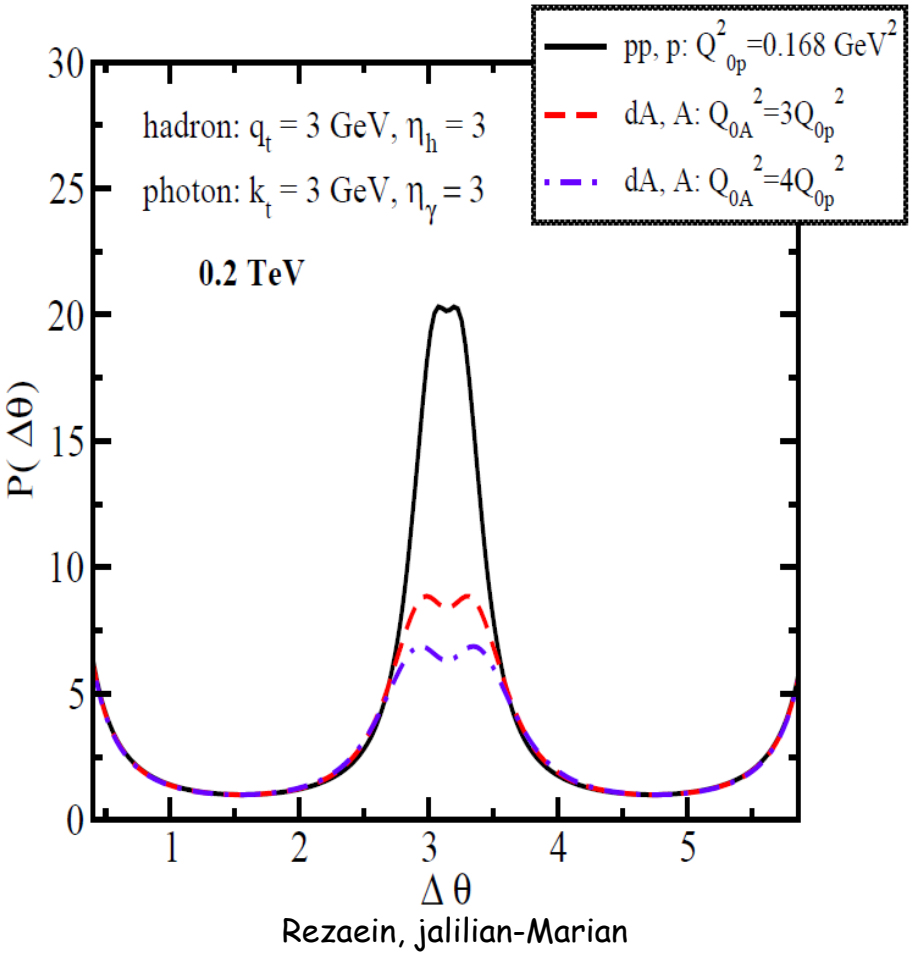
Both real and virtual (DY) photons

Forward CNM Physics - III

STAR has already observed suppression of the away side peak in the forward region in d+Au collisions

Q_S via direct photon+hadron correlations (DY also), in pA, pp





Rezaein, jalilian-Marian

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A Link Between CNM and Spin

RHIC is unique in its ability to collide polarized protons with nuclei

Exploiting the link between the TMD and CGC framework, it has been shown that transverse single spin asymmetries in polarized p+A collisions are sensitive to the saturation scale in the nucleus

$$\frac{A_N^{pA\to hX}}{A_N^{pp\to hX}} \underset{p_T^h<<Q_s^2}{\approx} \frac{Q_{s,p}^2}{Q_{s,A}^2} f(p_T^h) \qquad \frac{A_N^{pA\to hX}}{A_N^{pp\to hX}} \underset{p_T^h>>Q_s^2}{\approx} 1$$

[Kang, Yuan, PRD84 034019]

A_N measures the azimuthal modulation of particle/jet production with respect to the proton's spin

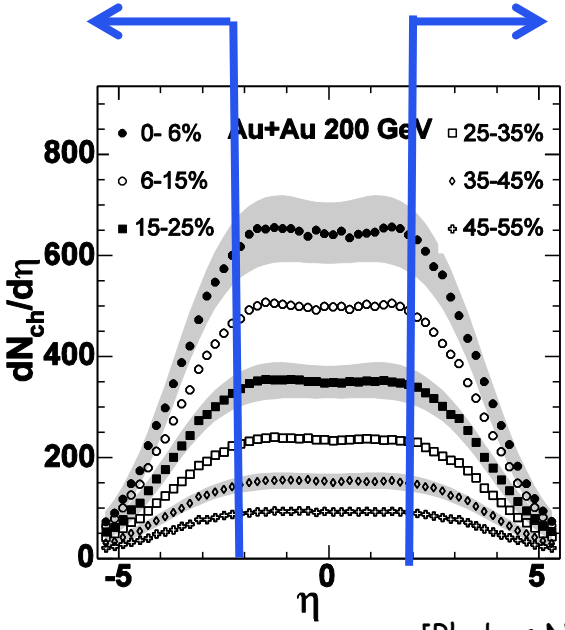
These spin effects are large. Spin "R_{AA}" could be ~O(0.5)

Forward Heavy Ion Physics

An area largely pioneered by PHOBOS and BRAHMS. We hope to expand upon their measurements (away from Bjorken plateau)

At forward rapidities

- Direct photons can give information about the expansion of the medium
- Correlation measurements can test models of longitudinal expansion (3d hydro)
- Extended (di-)jet coverage to study jet energy loss in the medium



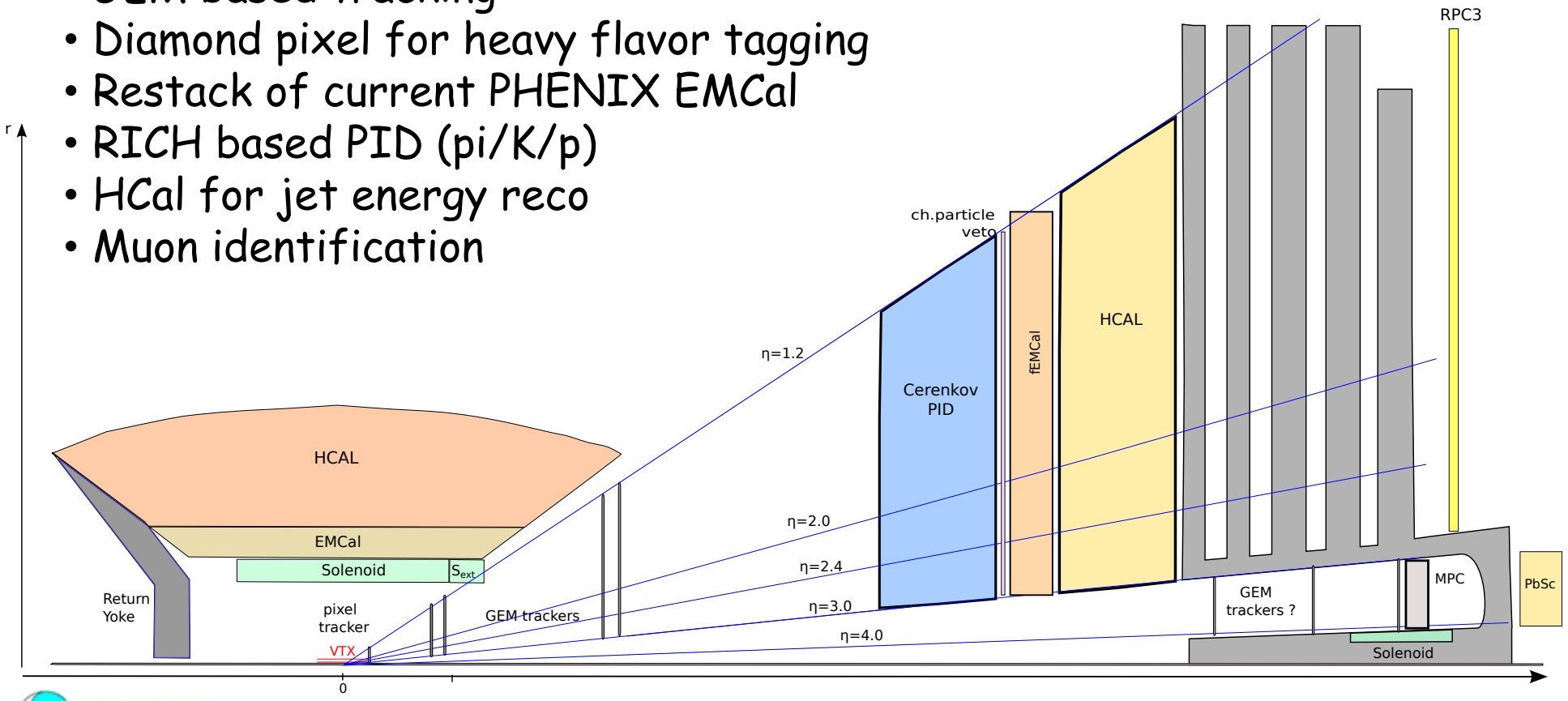
[Phobos NPA 757]

Currently it is question of how far forward the measurements will be able to be made

Forward sPHENIX

Optimized for jets and photons/DY over a large range in rapidity (η~4)

- Extension/modification of the central solenoid for B field
- GEM based tracking
- Diamond pixel for heavy flavor tagging
- Restack of current PHENIX EMCal
- RICH based PID (pi/K/p)
- HCal for jet energy reco
- Muon identification



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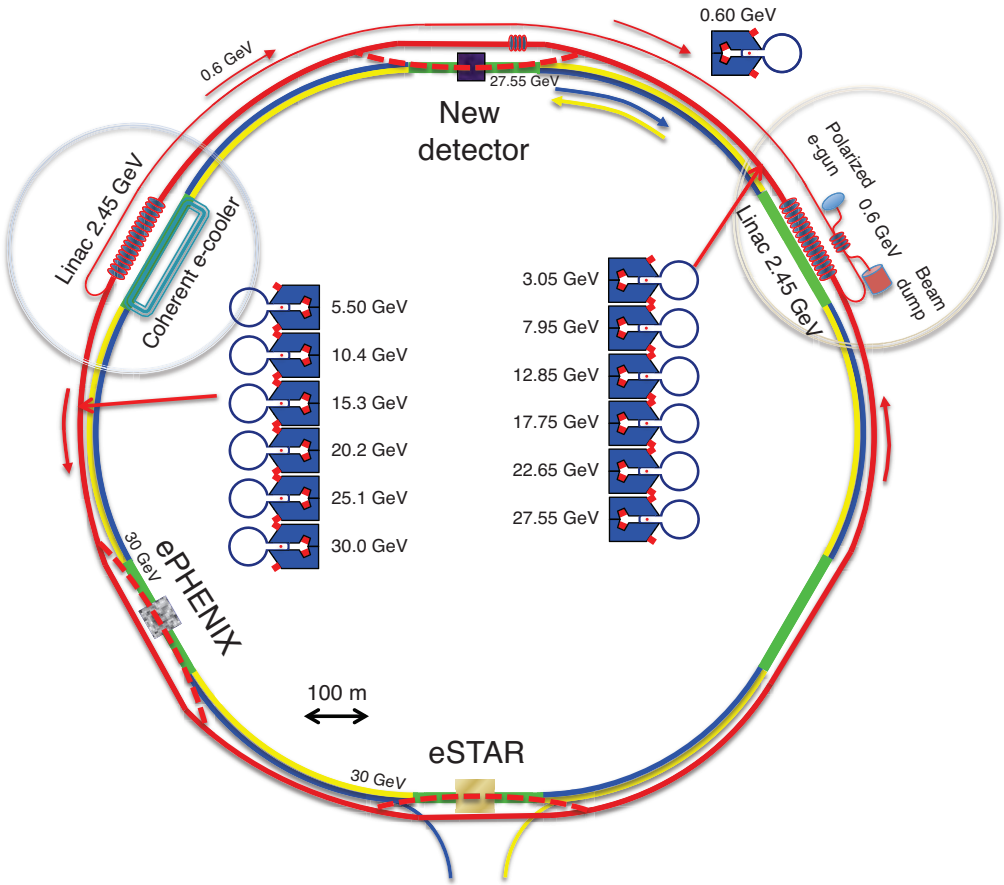
EIC and eRHIC



- One possible manifestation of EIC is eRHIC
- eRHIC will add electron accelerations capabilities to RHIC
- eRHIC is thought to happen in two stages (the difference being the electron beam momentum)
- Through the sPHENIX/decadel plan exercise, BNL charged the RHIC collaborations to imagine how their upgrades could lead to detectors for phase I of eRHIC

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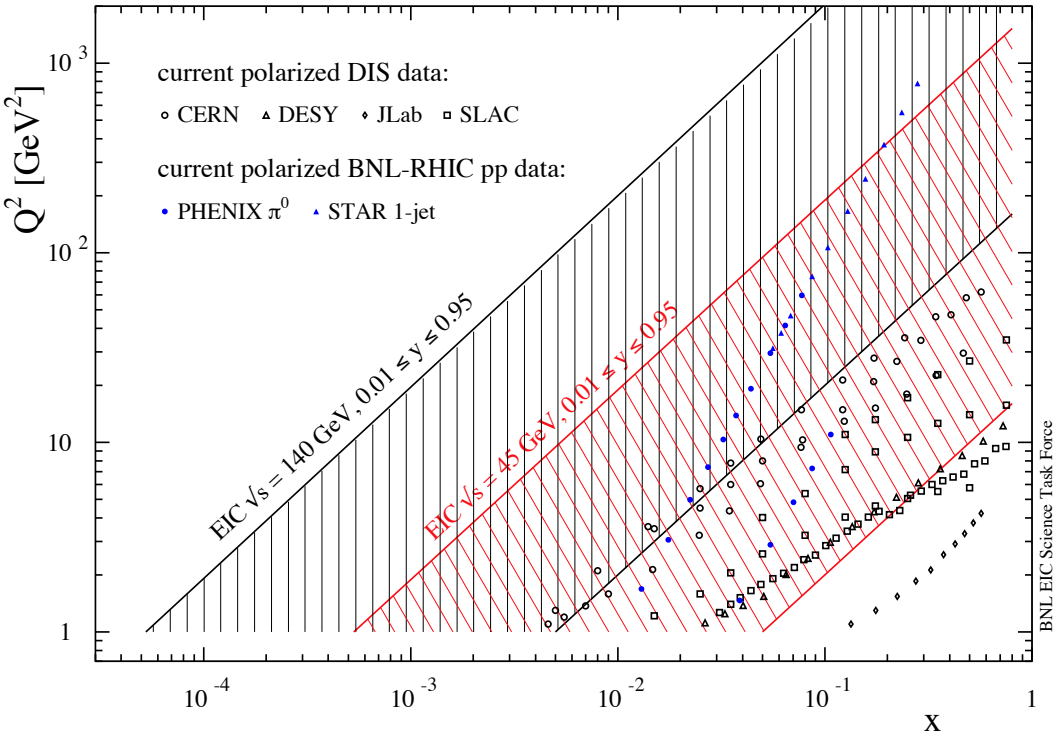
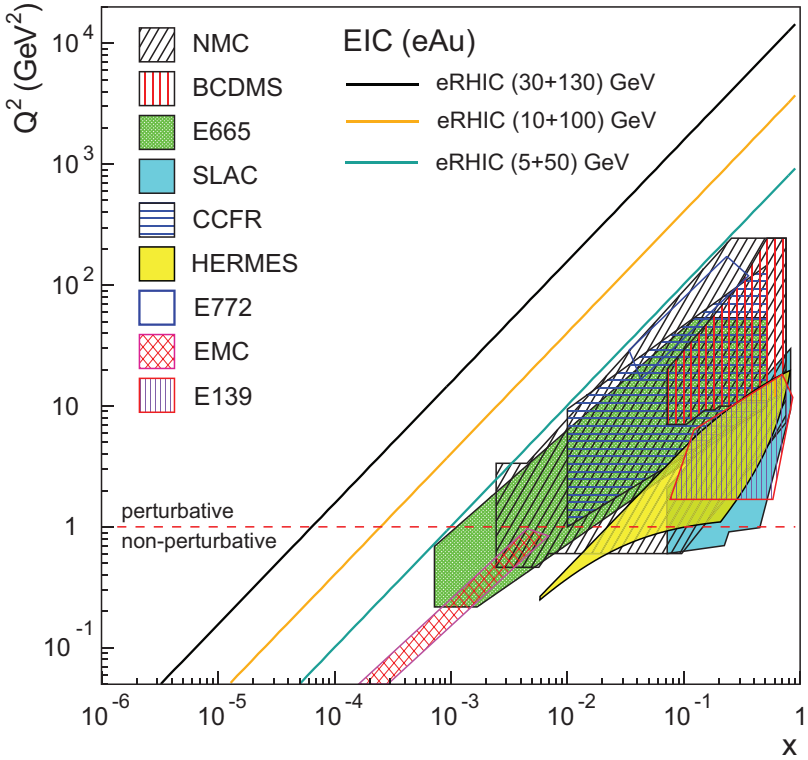
ePHENIX Physics

- The purpose of eRHIC is to measure the 3d structure of the nucleon and nuclei over a large kinematical range





- ePHENIX needs to measure the scattered electron and complete and exclusive final states

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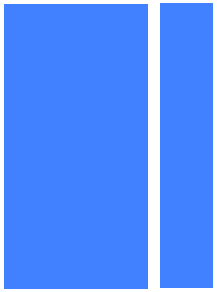
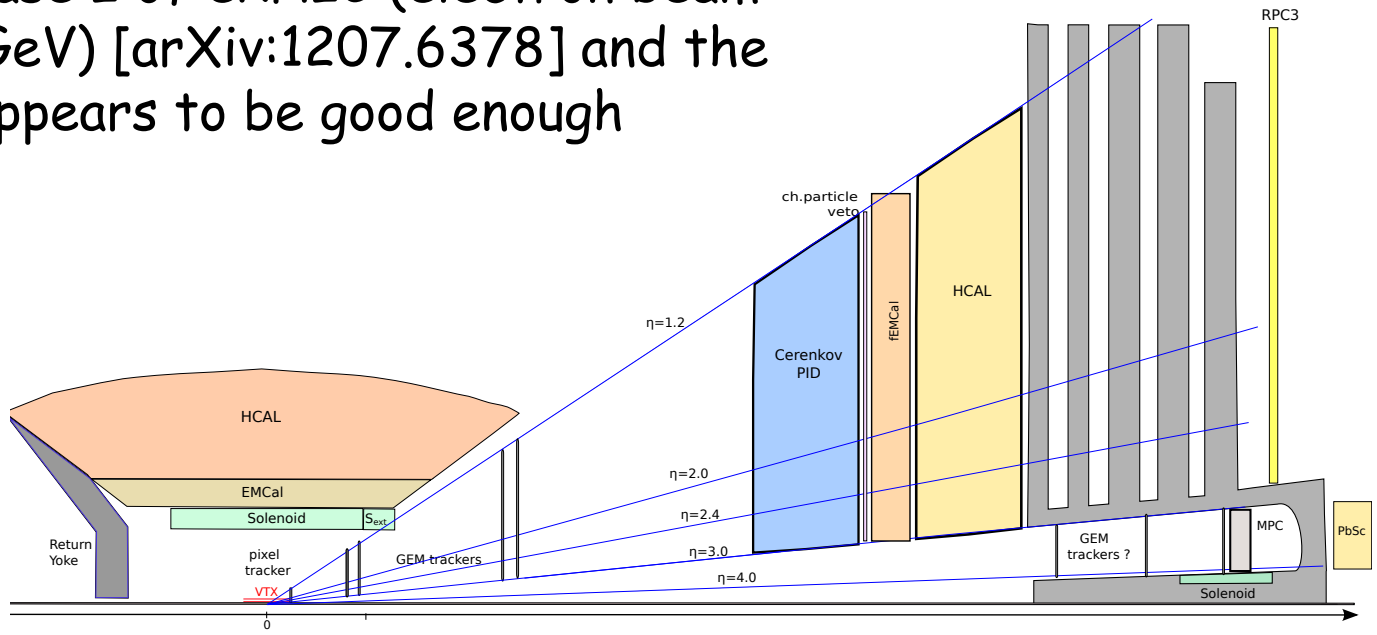
sPHENIX to ePHENIX

- Many studies were done to test the central barrel design for the phase I of eRHIC (electron beam momentum <= 10 GeV) [arXiv:1207.6378] and the current designs appears to be good enough

EMCal + Tracker





- Forward sPHENIX is being designed with ePHENIX in mind
- A forward EMCal + tracker on the opposite side will need to be added for ePHENIX

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Conclusions

- RHIC has a vibrant and varied physics program
- There is much to do that can only be accessed by going to the forward direction
- Forward sPHENIX is being designed and optimized to study forward jets, photons and DY
- Sensitivity studies are ongoing
- eRHIC is a possible future avenue for RHIC which would allow for precision measurements of the partonic structure of the proton and nuclei
- An evolution of sPHENIX to ePHENIX is being planned for in the design of sPHENIX

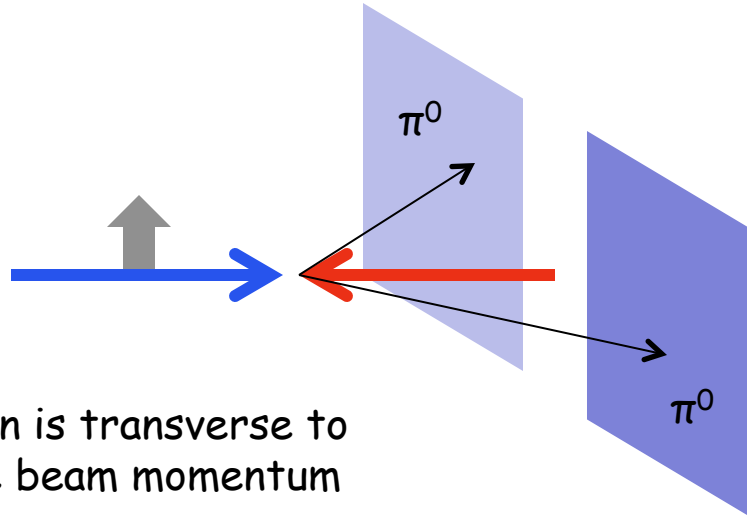
Backups

A_N

$$A_N^h = \frac{\sigma_L^h - \sigma_R^h}{\sigma_L^h + \sigma_R^h}$$

A_N (analyzing power) is a left-right (about the spin) asymmetry in particle production

Occurs in processes where one beam is transversely polarized and the other is unpolarized



Spin is transverse to the beam momentum